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ABSTRACT

The effectiveness of audiotutorial and teacher-directed inquiry in promoting school achievement was explored. High school biology students from two dissimilar populations were administered ten Piagetian-styled tasks to determine the student's operational level. Analysis of data on operational level and age determined that inner-city students (N=41) were at a significantly lower operational level and found to be significantly older than rural students (N=115). Random assignments of instructional treatments to groups of students within intact classes were made, where each group was instructed by the same teacher and covered identical instructional units. Summative testing following the end of the instructional period was analyzed for difference in mean achievement due to treatments and level of cognitive development. Results showed that there was no significant treatment effect in within-school comparisons; there was a significant difference in mean achievement in favor of the formal operational students. Significant differences were found in all between-school comparisons except when inner-city concrete operational students in the audiotutorial group were compared with rural concrete operational students in either treatment. Implications of the use of the audiotutorial format with students stabilized at the concrete operational level are discussed. (CS)

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The Effect of Instructional Mode On School Achievement of Concrete And Formal Operational Students

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INTRODUCTION

Based upon their observations of cognitive development for Swiss children, Inhelder and Piaget[1] indicated that formal operations begin to develop between the ages of 11 and 12. In deference to this generalized time frame, recent studies indicate that approximately 50 percent of secondary school students have not reached the formal operational stage.[2-5] Further, for samples of disadvantaged high school students, Nordland, Lawson, and Kahle[6] found both a lower incidence of formal thought development and incomplete decalage (generalization of operations for a particular state) of concrete conservation operations. Kohlberg and Mayer[7] have indicated that the development of formal operations is more dependent on the extent of horizontal decalage of concrete operations than the age of their onset. Instructional units incorporating direct confrontation with problems requiring concrete reasoning could have, therefore, a two-fold effect: generalization of concrete logical thought and an increase in the probability for formal thought development.

The purpose of this study was to explore the effectiveness of an audio-tutorial (A-T) and a teacher directed inquiry (TDI) mode in promoting school achievement on units presenting concrete reasoning problems for samples of students differentiated by their development of formal thought and completeness of decalage on concrete and formal conservation tasks.

METHODS

Subjects

The study employed subjects enrolled in introductory high school biology classes at an urban, senior high school and a rural, consolidated high school. The initial sample at the urban high school consisted of 55 students. Because of excessive absenteeism, change in school, or personal problems, 25 percent of the sample did not complete the study. The mean age of the 41 urban subjects completing the study was 16.2 years; mean age for the 115 rural high school subjects was 14.2 years. Standardized measures of achievement and ability were obtained 4 months prior to the experimental period for all subjects. All subjects had been assigned by computerized scheduling into three class periods at both schools.

Materials and Procedures

Random assignment of an audio-tutorial instructional format (A-T) to two classes and a teacher directed inquiry format (TDI) to one class was made following the Piagetian testing at each school. Each class was instructed by the same teacher, one at the urban school and two team teachers at the rural school. The treatment groups covered identical instructional units having in common printed study guides, behavioral objectives, tangibles, additional experiments and final summative test. The four units included direct confrontation with problems of conservation of physical quantity, the structure of grouping (Grouping I: Primary Addition of Classes), the concept of reversibility of cognitive operations and controlled experimentation employing two variables. In addition, 35 mm color slides were produced for the TDI treatment illustrating problems based on the written objectives of each unit. Time allowed for instruction was determined by the student's pace through the units. Summative testing directly followed the end of the instructional period.

Test Instruments

Ten Piagetian styled tasks, individually administered, determined the subject's operational level. The tasks were conservation of (1) number, (2) substance, (3) continuous quantity, (4) length, (5) area, (6) weight, (7) volume using clay, (8) volume using blocks; the Separation of Variables and Equilibrium in the Balance. Material apparatus, protocols, evaluation, and scoring of the tasks followed procedures used by Nordland, Lawson, and Kahle[6] for conservation of number through weight; Lawson, Nordland, and Devito[8] for conservation of volume using clay and blocks; and Piaget, Inhelder and Szeminska[9] for the two formal tasks.

Subjects were interviewed by three testers at the urban high school and five testers at the rural high school. Consistency between testers' scoring was determined by analysis of variance. The hypothesis that there is no difference in mean scoring between testers was not rejected at both school ($F = 1.55$, $p = 0.223$; $F = 1.45$, $p = 0.222$ for urban and rural schools, respectively). Achievement values were obtained from the subject's raw scores on the summative test covering all four units. The items were judged by teachers in science education to assess the content and cognitive processes of the instructional objectives. The reliabilities of this 32 item test, calculated by the Kuder-Richardson formula 20, were 0.71 and 0.78 for the urban and rural samples respectively. Item analysis indicated that the test was composed primarily of items in the average (0.51 - 0.75) and hard (0.26 - 0.50) difficulty levels and that a majority of the items (21 and 23) discriminated among the achievement levels of the urban and rural subjects respectively.

RESULTS

The operational level of the subjects determined by the total scores of the Piagetian tasks are shown in Figure 1. Comparison of the two samples using the Kruskal-Wallace[10] one-way analysis of variance by rank indicated a significant difference in operational level in favor of the rural sample ($H = 20.29$; $p < .001$). Differences in the percent of students exhibiting conservation of IIB tasks (68 vs. 89 percent) and IIIA tasks (24 vs. 44 percent) in both cases favored the rural sample.

Insert Figure 1 about here.

The difference in mean age was also significant ($F = 202.1$; $p < .000$): the urban sample was older by an average of two years. Correlation of mean age with total Piagetian scores indicated a significant, negative correlation for the urban sample ($r = -.245$) and an insignificant, positive correlation for the rural sample ($r = .101$). Correlation between cognitive level and the following standarized measures, STEP Reading and Science and SCAT Verbal and Quantitative, were all significant ($p < .01$) for both samples. Individual Pearson r's ranged from 0.331 to 0.402.

Differences in mean achievement between the treatment groups were analyzed by a one-factor analysis of variance (Table I). No significant differences were found. Therefore, prior to analyzing differences in mean achievement for treatment groups subdivided between concrete and formal operational students, data for the two A-T treatments were pooled.

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Insert Table I about here.

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Within school comparisons of mean achievement for treatment groups subdivided between conrete and formal operational students were made for all possible comparisons. Means and F-ratios of the individual ANOVA's are reported in Tables II and III.

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Insert Tables II and III about here.

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Between school comparison of mean achievement for treatment groups subdivided between concrete and formal operational students were made for all possible comparison. Results of the individual ANOVA's are reported in Table IV.

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Insert Table IV about here.

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DISCUSSION

Comparison of the total scores on the Piagetian tasks between the two samples indicated that they represented two different high school populations. The majority of the urban subjects (78.1 percent) were categorized as concrete operational, while 21.9 percent were judged as developing early formal thought. Classification of the rural high school sample indicated an even distribution between the concrete stage (45.3 percent) and the early formal stage (50.4 percent); 4.4 percent were judged as formal thinkers. When compared to the rural sample, the urban subjects not only lagged further behind in cognitive development but also did so at a significantly older age. These findings coupled with the observation of incomplete decalage on the concrete conservation tasks for these students indicates that the major difference between the samples is the stabilization of the urban subjects at the concrete operational level.

For the rural sample level of cognitive development, not instructional mode appears to be the primary determinant of achievement levels (Table II). These achievement scores reflected an understanding of concrete concepts and factual information, as only four of the thirty-two items required formal reasoning ability. Since moderately significant correlations were found between cognitive level and the selected standardized measures, differences in achievement between concrete and formal operational students may be due to both differences in the level of cognitive functionality and differences in the availability of relevant subsuming concepts in the cognitive structure of the students. Further, Kohlberg and Mayer[7] indicate a stage dependent relationship between cognitive development and development of individual self concept. It seems reasonable

that such a relationship may extend to the development of academic self concept. Students capable of formal operations, therefore, may enter new learning situtions with a higher level of confidence in their ability to successfully acquire new information and concepts.

Although the comparison of achievement means for the intact urban treatment groups was not statistically significant (Table I), the achievement means of the two A-T groups were higher than the mean of the TDI group. Further, significant differences were found in all possible between school comparison except for those comparing urban concrete operational subjects in the A-T group with rural concrete operational subjects in either treatment (Table IV). While the relative differences in mean achievement still favored the rural sample, this finding is of particular importance in light of the extreme cognitive development difference shown to exist between these samples. The pattern of these results indicate that the self-paced audio-tutorial instructional mode is more likely to ameliorate the problems of low verbal and science abilty and sporadic school attendance common for this population. If stabilization of a particular stage of development impedes further cognitive growth, then the goal of providing a meaningful instructional alternative in terms of increased levels of school achievement should not be overlooked. The long term effect of increased academic success on individual self-concept and generalization of concrete cognitive operations may provide an avenue to increase the incidence of formal thought development for such populations. In this regard A-T may provide a viable alternative approach for students stabilized at the concrete operational level.

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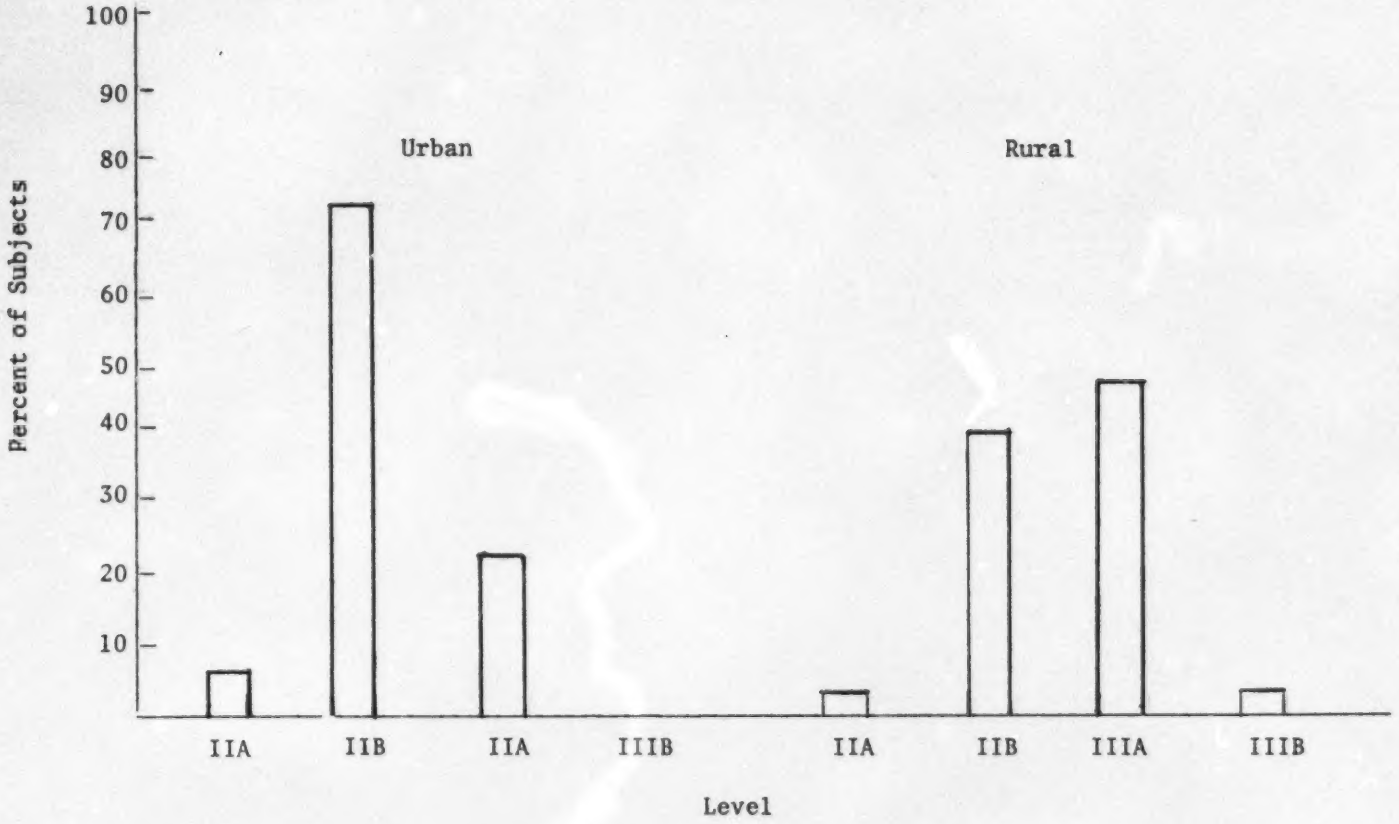

Figure 1

Operational Level of the Subjects

TABLE I

Comparison of Mean Achievement Scores

by Treatment Group, Analysis of Variance

School	Treatment	N	Mean	F	F-Probability
	AT	9	16.1	0.706	0.500
Urban	AT	17	16.8		
	TDI	15	14.5		
	AT	42	20.4	1.304	0.276
Rural	AT	37	19.7		
	TDI	36	21.5		

TABLE II

Within School Comparison of Mean Achievement for Treatment Groups

Subdivided Between Operational Level, Rural Sample

Treatment x Cognitive Level		A-T Concrete	A-T Formal	TDI Concrete	TDI Formal
	Means	17.90	22.45	18.00	23.25
A-T Concrete	17.90	-	21.76**	0.005	26.94**
A-T Formal	22.45		-	9.30**	0.57
TDI Concrete	18.00			-	14.92**
TDI Formal	23.25				-

** $p < 0.01$

TABLE III

Within School Comparison of Mean Achievement for Treatment Groups

Subdivided Between Operational Level, Urban Sample

Treatment x Cognitive Level	Mean	F
A-T Concrete	15.15	0.99
TDI Formal	13.67	

TABLE IV

Between School Comparison of Mean Achievement for Treatment Groups

Subdivided Between Operational Level

School		Rural				
	Treatment x Cognitive Level					
		Means	17.90	22.45	18.00	23.25
	A-T Concrete	15.15	3.449	36.67**	3.220	47.18**
	TDI Concrete	13.67	9.720**	39.06**	6.790*	57.40**

* $p < 0.05$

** $p < 0.01$